A comparison of woods for acoustic guitar soundboards

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Abstract. The soundboards of guitars have been crafted from wood since the beginning of string instruments. Based on industry-specific criteria, soundboards have traditionally been made from spruce and a few selected tropical wood species. This paper aims to find potential U.S. hardwoods that can serve as viable options to supplement the current manufacturing needs of the guitar industry. This paper also identifies the properties within the industry-specific criteria and determines how each property contributed to the market success of the soundboard woods used in production. The woods were separated into spruces, other woods in production, and U.S. hardwoods. A decision matrix determined which U.S. hardwoods would make viable options for production-grade soundboards. Basswood has the most promise of being a supplemental option.

Keywords: Tonewoods; Acoustic guitar; Engineering materials; Soundboards

Introduction

Wood has been used for the bodies of stringed instruments since the earliest times. As stringed instruments evolved, a common form emerged: a hollow body with a flat top or soundboard and a long neck. While decorative elements varied, the structures were almost always made of wood. The acoustic guitar emerged from Europe and the United States in roughly its modern form by the middle of the 19th century (Turnbull 1974).

Soundboards, or tops, are predominantly made from a few species of conifers, mainly spruce (genus *Picea*). However, a small number of steel-string guitars use tropical woods. Most acoustic guitars have a top with an "hourglass" shape, with the lower part, or lower bout, being longer and broader than the upper part or upper bout. The soundboard's waist separates the upper and lower bouts. Figure 1 displays a basic diagram of an acoustic guitar.

Soundboards are made from quarter-sawn wood to obtain the wood with the most dimensionally stable properties. Soundboards are usually made by book-matching, "a process in which a plank is split and opened up in the same manner as opening a book" (French 2012, 138). The two boards are then joined together at a seam along the grain to make a soundboard. Book matching two boards requires large diameter logs, which can only be obtained from harvesting old-growth trees.

Traditionally, old-growth spruce trees are used to make soundboards for acoustic guitars. However, the old-growth spruce the guitar industry uses is quickly diminishing due to the expected quality of wood. The quality of wood used for guitar tops is exceptionally high; some even consider it rare (Gibson and Warren 2021). Guitar builders prefer tops with "straight, even grain with closely spaced growth rings, which is relatively stiff when flexed by hand across the grain, and rings well when held lightly and tapped with a fingertip" (French 2022, 61). The industry may need to look to other woods to keep up with its manufacturing needs. This paper aims to determine if U.S. hardwoods are a viable option for supplementing the production of acoustic guitar soundboards.

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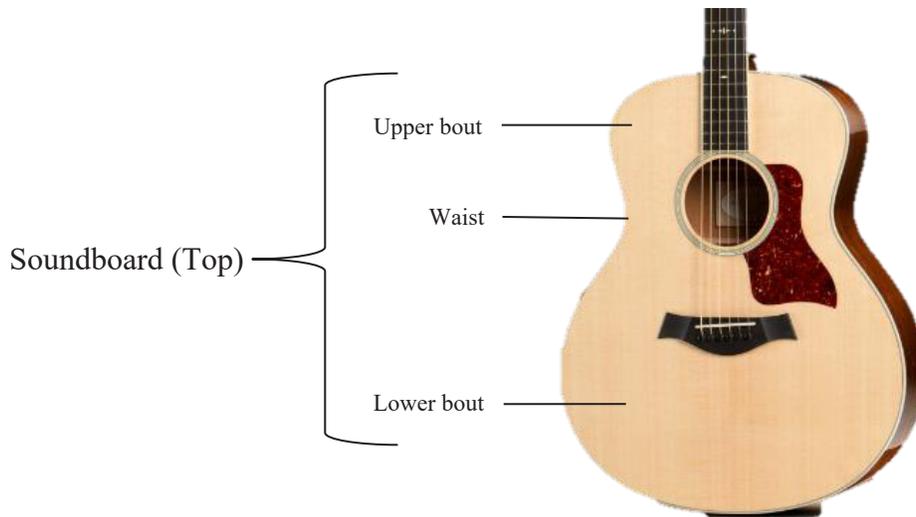address: Knoy Hall of Technology, 401 Grant St, West Lafayette, IN 47907

Figure 1. Basic diagram of an acoustic guitar's soundboard (Taylor Guitars 2024).

Materials and methods

Woods

Spruce is the most common material used for guitar tops. Sitka spruce (*Picea sitchensis*) is the most commonly used spruce for guitar tops, making up approximately 80 percent of all guitars in production worldwide (CMUSE 2022). Taylor Guitars, a major American guitar manufacturer, makes 85%–90% of their guitars with Sitka spruce tops (Taylor Guitars 2024). Other spruces used in acoustic guitar soundboards are Engelmann (*Picea engelmannii*), red (*Picea rubens*), white (*Picea glauca*), European (*Picea abies*), and Lutz (*Picea* x lutzii).

Due to the limited supply of the quality spruce wood necessary for acoustic guitar soundboards, the market currently offers alternatives to spruce-top guitars. Most of the major American guitar companies, including Fender, Taylor, and Martin, offer tops that are not of spruce. Fender uses hardwoods such as mahogany (*Swietenia macrophylla*), sapele (*Entandrophragma cylindricum*), and agathis (*Agathis australis*). Taylor uses hardwoods such as mahogany, koa (*Acacia koa*), walnut (*Juglans nigra*), big leaf maple (*Acer macrophyllum*), and softwoods like western red cedar (*Thuja plicata*) and sinker redwood (*Sequoia sempervirens*). Martin uses sinker redwood.

One untapped resource that has the potential to be wood for acoustic guitar soundboards is domestic U.S. hardwoods. A few domestic hardwoods, like walnut, are rarely used for soundboards but are commonly used for other guitar parts. This paper considers basswood (*Tilia americana*), swamp ash (*Fraxinus genus*), yellow poplar (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), birch (*Betula alleghaniensis*), and red alder (*Alnus rubra*) as possible soundboard options. These woods were chosen because they are either used in the production of other stringed instruments or other parts within the acoustic guitar body.

Given this selection of woods for guitar-making, this paper looks to prove if domestic U.S. hardwoods can supplement the existing materials based on their structural, acoustic, and aesthetic characteristics. Based on the number of hardwoods in industry standard guitars, domestic U.S. hardwoods should be a viable supplemental option.

Method

Choosing the right wood for an acoustic guitar soundboard is vital to the instrument as the soundboard is responsible for its tonal quality (Pessler 2024). This study selected three types of wood: spruces used in acoustic guitar production, non-spruce wood used in guitar production, and U.S. domestic hardwoods known to be associated with guitar soundboards. Using the selection criteria commonly used among luthiers, the acoustic, structural, and aesthetic properties of spruce and non-spruce wood used in acoustic guitar production were ranked based on a decision matrix.

After the values were recorded and ranked, the study applied the same method to the selected U.S. domestic hardwoods. The hardwood properties were then compared to that of the properties of the spruce and non-spruce wood used in acoustic guitar production.

Selection criteria

Pedgley et al. (2009) state that "regardless of material, all acoustic guitar soundboards must satisfy three basic design criteria: structural, acoustic, and aesthetic" (p. 160). Their paper elaborates on these criteria by explaining that

> "the designer's task is to devise a soundboard with freedom to move (to satisfy acoustic criteria), whilst at the same time resisting twisting, bowing and other displacements that can arise from string tension (to satisfy structural criteria); and assuming the structural and acoustic criteria are met, the final requirement is for the soundboard to possess attractive sensorial properties (to satisfy aesthetic criteria)" (p. 160).

Structural criteria

The material properties are a crucial factor in selecting wood for tops. The four significant material properties are density, stiffness, hardness, and strength. Guitar builders use low-density wood, as it makes the guitar lightweight and has more tonal complexity (C.F. Martin & Co., Inc. 2025a). Merchel et al. (2019) furthered this idea by concluding that low density and low Young's modulus of the soundboard positively impact the guitar's sound quality. The relationship between Young's modulus and density is used to determine a widely referenced metric for selecting tops: specific stiffness. Specific stiffness, or stiffness-to-weight ratio, is Young's modulus in the longitudinal direction, E_L, divided by the density, ρ, of the material and is denoted as (Gore and Gilet 2011). Young's modulus is known as the modulus of elasticity (MOE).

Guitars are designed to have the lowest damping possible. Wood's hardness is related to its internal damping, as harder woods have low damping and accentuate higher frequencies (Acoustic Guitarist 2025). The Janka hardness scale measures wood hardness. Woods with higher Janka hardness values have less internal damping. Damping is also an acoustic property and can be found via modal testing.

Wood strength is a secondary material property, as stiffness is proportional to compression strength parallel to the grain. When strength is increased, so is stiffness. A stiff soundboard is also a strong soundboard, so wood with higher strength would better resist the tension of the strings across the guitar's bridge.

Acoustic criteria

Soundboard materials are characterized by four acoustic properties: material speed of sound, sound radiation coefficient, characteristic impedance, and damping. Ideally, acoustic guitar soundboard woods have a high speed of sound, high sound radiation coefficient, low characteristic impedance, and low damping.

The speed of sound through an orthotropic material, like wood, varies depending on the direction of the grain in relation to the measurement. This occurs because a material's speed of sound is dependent on material properties. The material's speed of sound, c, equation is

$$c = \sqrt{\frac{E_L}{\rho}} \qquad (1)$$

"Light wood with high stiffness along the grain has a higher speed of sound" (French 2022, 248). The speed of sound through a material is directly proportional to the material's sound radiation coefficient and characteristic impedance. A material's sound radiation coefficient, R, relates to how quickly sound can radiate from the material. A high sound radiation coefficient means a louder sound. The sound radiation coefficient (SRC) equation is

$$R = \frac{c}{\rho} = \sqrt{\frac{E_L}{\rho^3}} \qquad (2)$$

Bucur (2006) stated that high-quality resonance wood should have the highest sound radiation coefficient and the lowest acoustic impedance. The material's acoustic impedance of acoustic guitar soundboards is the mechanical input impedance. This term is purely resistive and real (Rossing and Fletcher 2004). Mechanical input impedance, Z_0, is expressed by its equation,

$$Z_0 = c\rho = \sqrt{E_L \rho} \qquad (3)$$

The soundboard's ability to efficiently radiate sound is fundamental to the guitar's overall tonal characteristics and projection. The ideal soundboard would ring like a bell, meaning the higher resonance frequencies of the soundboard ring for a more extended period. Every resonance frequency rings in the same number of cycles. The bell-like sound radiates more cycles, thus reaching higher frequencies. Higher frequencies can be heard when there is low damping.

Damping refers to absorbing or dissipating vibrational energy in the context of an acoustic guitar soundboard. Damping can be calculated via the half-power bandwidth method. According to ASTM (2017), the half-power bandwidth, also known as the 3dB method, works by

> "using the response curve from each mode, measure the resonant frequency and the frequencies above and below the resonant frequency where the value of the response curve is 3 dB less (the 3 dB down points)

than the value at resonance. The frequency difference between the upper 3 dB down point and the lower 3 dB down point is the half-power bandwidth of the mode. The modal loss factor (η) is the ratio of the half-power bandwidth to the resonant frequency" (p. 6).

This method is predicated on the following equation:

$$\eta = 2\zeta = \frac{1}{Q} = \frac{\Delta f_{3dB}}{f_n} \tag{4}$$

Where ζ is the damping ratio, Q is the quality factor, Δf_{3dB} is the difference between the left and right frequencies (in Hz) when moving 3dB down the FRF, and f_n is the frequency (in Hz) of the nth mode. The quality factor is inversely related to damping. So, to achieve the desired low damping, Q needs to be an enormous value (French 2022). This variable is unitless. This method is depicted in Figure 2.

Aesthetic criteria

The end user (guitar player) visually values the aesthetics of guitars. Usually, the player must be attracted to how the guitar looks so that they will consider playing the instrument. On one end of the spectrum, some players will only consider an instrument they think is attractive. It does not matter how good it sounds in those cases – the player will never know. On the other end of the spectrum, other players may give the unattractive guitar a chance if they know who made the guitar and what materials went into making it. Pedgley et al. (2009) surmise that "wood is a material rich in visual, tactile,

and olfactory properties and is regarded as a memento of the power, beauty, and lifecycle of nature" (p. 162).

Decision matrix

A decision matrix was used to compare the wood's material properties within each group. To summarize the tables in the Results section, let us look at the guitar industry's benchmark material, Sitka spruce. Using Table 1, Sitka spruce has a density of 425 kg/m³, MOE of 11.03 GPa, specific stiffness of 27.5 x 10⁶ m²/s², Janka hardness of 2270 N, and compression strength parallel to the grain of 38.2 MPa. Based on the score ranges in Table 4, Sitka spruce has a density that falls within the score of "1", MOE score of "0", specific stiffness score of "5", Janka hardness score of "5", and strength score of "5". Using the weight multipliers in Table 2, the weighted score of Sitka spruce's density is "1" multiplied by four, which equals "4". Its weighted score for MOE is "0" multiplied by three, which equals "0". The weighted score of specific stiffness for Sitka spruce is "5" multiplied by five, which equals "25". Sitka spruce's Janka hardness weighted score is "5" multiplied by one, which equals "5". Finally, the weighted score for compression strength parallel to the grain is "5" multiplied by two, which equals "10". These weighted values are presented in Table 6, as well as the total scores that were used to create Figure 3. This method was used for the non-spruce wood soundboards in production material property rankings. The decision matrices were used to establish which material properties the guitar industry favors so that the U.S. hardwoods selected in this paper could be compared to what was already in production.

Results

Spruces as soundboards

Through the decades, guitar builders have found that old-growth spruce woods fit the criteria best. Old-growth woods are used for their size, as well as their stable and predictable properties. Table 1 shows the material properties and aesthetics of commonly used spruce woods for acoustic guitar soundboards, sourced from Eric Meier's book, *Wood! Identifying and using Hundreds of Woods Worldwide* (2015) and Lisa Black's thesis, *Tonewood: An Environmental Perspective* (2013).

The spruces can be ranked based on the material properties of density, modulus of elasticity (MOE), specific stiffness, hardness, and compression strength parallel to the grain. Using a decision matrix, the species can be objectively ranked on a scale from zero to five. Tables 2–5 show the breakdown of the decision matrix.
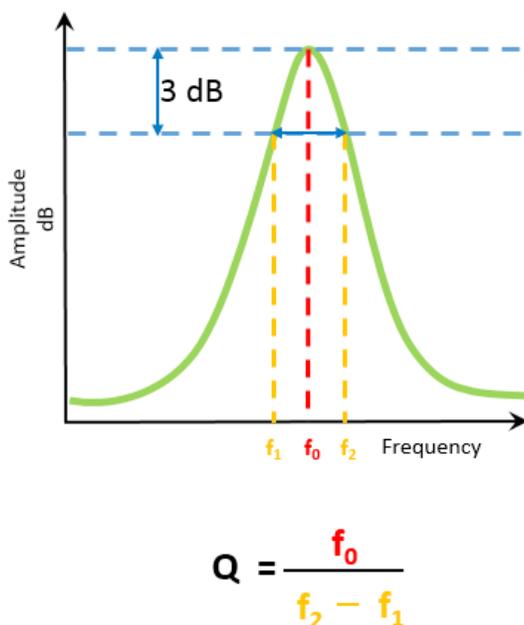

$$Q = \frac{f_0}{f_2 - f_1}$$

Figure 2. Depiction of the half-power bandwidth method (Siemens 2020).

Table 1. Mechanical property values and grain pattern descriptions for spruces used as guitar soundboards.

Woods	Scientific name	Density, ρ (kg/m³)	MOE, E_L (GPa)	Specific stiffness, (10^6 m²/s²)	Janka hardness, J (N)	Strength, σ (MPa)	Grain pattern
Sitka	*Picea sitchensis*	425	11.03	27.5	2270	38.2	Fine, even texture; consistently straight (Meier 2015, 184)
Engelmann	*Picea engelmannii*	385	9.44	24.5	1740	31.5	Fine, even texture; consistently straight; small knots are common (Meier 2015, 183)
White	*Picea glauca*	425	9.07	21.3	2140	32.6	Fine, even texture; consistently straight (Meier 2015, 183)
Red	*Picea rubens*	435	10.76	24.7	2180	33.6	Fine, even texture; consistently straight (Meier 2015, 183)
European	*Picea abies*	405	9.70	24.0	1680	35.5	Fine, even texture; consistently straight (Meier 2015, 183)
Lutz	*Picea* x *lutzii*	425	10.05	24.4	2205	35.4	Texture and luster of white spruce (Black, 2013)

Table 2. Weights of material properties.

	Low	High	Weights
Density, ρ	5	0	4
MOE, E_L	5	0	3
Specific stiffness,	0	5	5
Janka hardness, J	0	5	1
Strength, σ	0	5	2

Table 3. Ranking assignments for each mechanical property.

	Density ρ	MOE E_L	Specific stiffness	Janka hardness J	Strength σ
5	0–394	0–9.25	26.5 +	2170 +	38 +
4	395–404	9.26–9.65	26.4–25.5	2169–2070	37.9–36.5
3	405–414	9.66–10.05	25.4–24.5	2069–1970	36.4–35
2	415–424	10.06–10.45	24.4–23.5	1969–1870	34.9–33.5
1	425–434	10.46–10.85	23.4–22.5	1869–1770	33.4–32
0	435 +	10.86 +	22.4–0	1769–0	31.9–0

Table 4. Unweighted rankings of spruces.

	Sitka	White	Engelmann	Red	European	Lutz
Density	1	1	5	0	3	1
MOE	0	5	4	1	3	3
Specific stiffness	5	0	3	3	2	3
Janka hardness	5	4	0	5	0	4
Strength	5	1	0	2	3	3
Totals	16	11	12	11	11	14

Table 5. Weighted rankings of spruces.

	Sitka	White	Engelmann	Red	European	Lutz
Density	4	4	20	0	12	4
MOE	0	15	12	3	9	9
Specific stiffness	25	0	15	15	10	15
Janka hardness	5	4	0	5	0	4
Strength	10	2	0	4	6	6
Totals	44	25	47	27	37	38

Table 6. Acoustic properties of spruces.

	Density, ρ (kg/m³)	MOE, E_L (GPa)	Speed of sound, c (m/s)	SRC, R (m⁴/(kg-s))	Mechanical impedance, z (kg/(m²s))
Red	435	10.76	4,973.5	11.43	2,163,469
Engelmann	385	9.44	4,951.7	12.86	1,906,410
European	405	9.70	4,893.9	12.08	1,982,044
Lutz	425	10.05	4,862.8	11.44	2,066,700
Sitka	425	11.03	5,094.4	11.99	2,165,121
White	425	9.07	4,619.7	10.87	1,963,352

Figure 3. Ranking spruces by material properties (Taylor Guitars 2024b, 2024c, 2024d; Forestry 2023).

Table 2 shows how the material properties are scored. Lower values are desired for density and MOE, so a score of "5" is given. A score of "0" is given to a spruce with high density. For specific stiffness, hardness, and strength, the opposite is true. Higher values are desired, so a score of "5" is given to the wood with the highest values. Table 2 also shows the weighted importance of each material property. The material properties are numbered from most significant to least, with a score of "5" being most significant and a score of "1" for least significant. The weighted score values were assigned to each material property based on the industry's majority consensus.

Table 3 applies a value range to each number ranking for each material property. For example, let's take the material property of density. The highest value of 435 was placed in the "0" category because a high-density value is not desirable. The lowest value of 385 needed to be in the "5" category so that the full range of scores was used. The best way to incrementally distribute the density values among the scores was to group them in counts of ten. The rest of the density scores were determined by looking at Table 1 and seeing where they fell on the chart.

Table 4 shows the scores of each material property based on the value ranges in Table 3. The scores were totaled without weighted values. This table shows the total scores of the material properties for each spruce as if they were equally considered. Table 4 shows that Sitka spruce is the best wood for acoustic guitar soundboards.

Table 5 shows the final weighted decision matrix, and Figure 3 depicts the results of Table 5. The weighted scores were found by adding the values in Table 4 with the weights in Table 2, Table 5, and Figure 3 show that if only material properties were considered when selecting materials for a soundboard, then Engelmann spruce would be the desired wood.

The material properties and aesthetics of tonewoods are only two influences on selecting a top for an acoustic guitar. The third is the material's acoustic properties. Table 6 shows the calculated speed of sound, sound radiation coefficient, and mechanical impedance of each spruce based on the equations in the previous section (Wegst 2006).

The data in Table 6 show that Sitka spruce has the highest speed of sound, and Engelmann spruce has the lowest mechanical impedance and highest sound radiation coefficient, attributed to its low density. Figure 4 shows the order in which the spruces are used in industry, from most common to rarely used.

Non-Spruce Soundboards in Production

Gore (2011) states that western red cedar and redwood show attributes of good woods for an acoustic guitar top. These woods' material properties and grain pattern affect their status as an acceptable replacement for spruce tops. Table 7 shows the material properties and grain pattern of the listed alternative wood for a guitar soundboard, sourced from Meier (2015). The woods listed below are both hardwoods and softwoods.

With Sitka spruce as a benchmark, Agathis is the only species with relatively close specific stiffnesses. The following two closest woods are western red cedar and sinker redwood. Western red cedar and sinker redwood are attractive alternatives due to their low densities. Sapele and Hawaiian Koa are the strongest materials in this selected group.

Based on the material properties, the current alternative tonewoods were ranked using the decision matrix method as the spruce woods. Tables 8–10 show the breakdown of the decision matrix, and Figure 5 shows the species ranked from best to worst mechanical properties.

The grain pattern is the next deciding factor. Of the selected tonewoods, Agathis comes closest to being the best alterna-
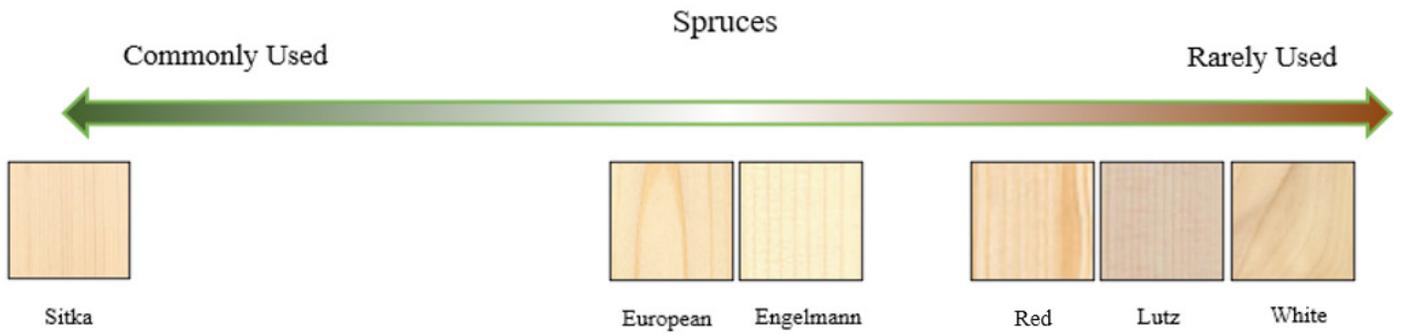
Figure 4. Order of use in industry for spruces (Taylor Guitars 2024b, 2024c, 2024d; Forestry 2023).
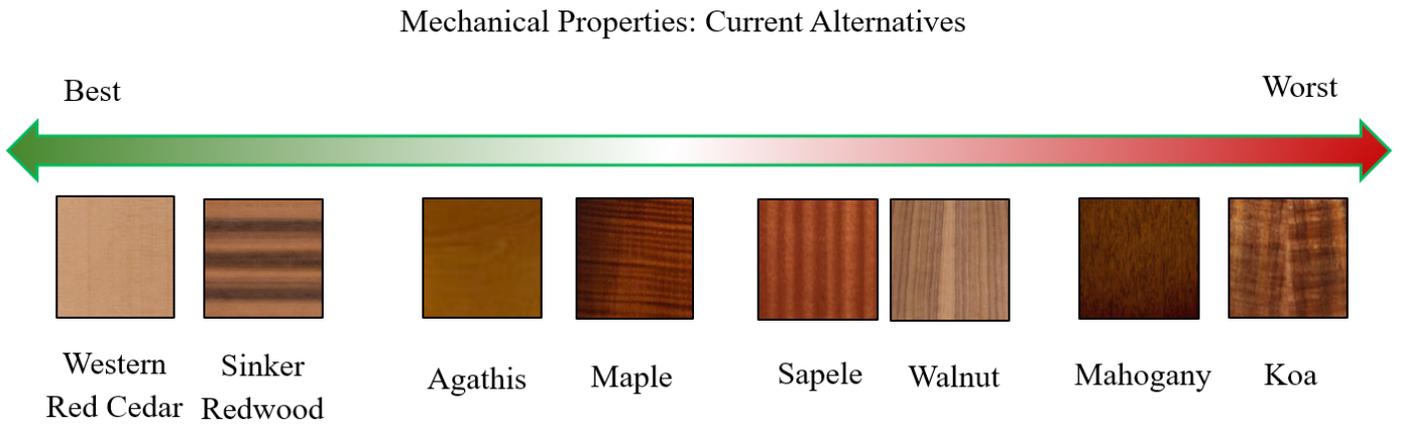

Figure 5. Ranking current alternatives by material properties (C.F. Martin & Co., Inc. 2025a; Taylor Guitars 2024a, 2024d; Andy king50 (2011))

Table 7. Mechanical property values and grain pattern descriptions for alternative tonewoods.

	Woods	Wood type	Scientific name	Density ρ (kg/m³)	MOE E_L (GPa)	Specific stiffness (10^6 m²/s²)	Janka Hardness J (N)	Strength Σ (MPa)	Grain pattern
Often used	Western red cedar	Softwood	*Thuja plicata*	370	7.66	20.7	1560	31.4	Straight grain with coarse texture (Meier 2015, 240)
	Mahogany	Hardwood	*Swietenia macrophylla*	590	10.06	17.1	4020	46.6	Medium and uniform texture; grain can be straight, interlocked, irregular or wavy (Meier 2015, 230)
Less used	Koa	Hardwood	*Acacia koa*	610	10.37	17.0	5180	48.7	Uniform medium to coarse texture; usually slightly interlocked and sometimes wavy (Meier 2015, 50)
	Agathis	Hardwood	*Agathis australis*	540	11.87	22.0	3230	42.3	Usually straight, with a fine, even texture (Meier 2015, 58)
	Sinker redwood	Softwood	*Sequoia sempervirens*	415	8.41	20.3	2000	39.2	Straight, coarse texture (Meier 2015, 224)
Rarely used	Walnut	Hardwood	*Juglans nigra*	610	11.59	19.0	4490	52.3	Usually straight, but can be irregular; medium texture (Meier 2015, 146)
	Sapele	Hardwood	*Entandrophragma cylindricum*	670	12.04	18.0	6280	60.4	Interlocked; fine uniform texture (Meier 2015, 122)
	Maple	Hardwood	*Acer macrophyllum*	545	10.00	18.3	3780	41.0	Straight, fine, even texture (Meier 2015, 54)

Table 8. Ranking assignments for each mechanical property.

	Density ρ	MOE E_L	Specific stiffness	Janka hardness J	Strength σ
5	0–445	0–8.04	21.5 +	5650 +	59 +
4	446–520	8.05–9.04	21.4–20.5	5649–5000	58.9–54
3	521–595	9.05–10.04	20.4–19.5	4999–4350	53.9–49
2	596–670	10.05–11.04	19.4–18.5	4249–3700	48.9–44
1	671–745	11.05–12.04	18.4–17.5	3699–3050	43.9–39
0	746 +	12.05 +	17.4–0	3049–0	38.9–0

Table 9. Unweighted rankings of current alternative tonewoods.

	Western red cedar	Mahogany	Koa	Agathis	Walnut	Sinker redwood	Sapele	Maple
Density	5	3	2	3	2	5	2	3
MOE	5	2	2	1	1	4	1	3
Specific stiffness	4	0	0	5	2	3	1	1
Janka hardness	0	2	4	1	3	0	5	2
Strength	0	2	2	1	3	3	5	5
Totals	14	9	10	11	11	15	14	14

Table 10. Weighted rankings of current alternative tonewoods.

	Western red cedar	Mahogany	Koa	Agathis	Walnut	Sinker redwood	Sapele	Maple
Density	20	12	8	12	8	20	8	12
MOE	15	6	6	3	3	12	3	9
Specific stiffness	20	0	0	25	10	15	5	5
Janka hardness	0	2	4	1	3	0	5	2
Strength	0	4	4	2	6	6	10	10
Totals	55	24	22	43	30	53	31	38

tive when favoring grain patterns. Maple is another species that has a desired grain pattern. The final criterion is based on the wood's acoustic properties. Table 11 shows the calculated speed of sound, mechanical impedance, and sound radiation coefficient of each current alternative tonewood.

Agathis has the desired high speed of sound, and western cedar has the preferred lowest mechanical impedance and the most significant sound radiation coefficient. Figure 6 shows the order of the current alternatives, from most common to rarely used.

Domestic hardwoods as possible woods for soundboards

Some domestic species are used in production for solid body electric guitars, like red alder, basswood, ash, and yellow poplar

(Ahvenainen 2019). Table 12 shows several selected domestic species with material properties and aesthetics that compare to the woods already in soundboard production, sourced from Meier (2015).

Basswood has the closest specific stiffness to spruce and has the ideal grain pattern for building an acoustic guitar top. Yellow poplar is another species with a higher specific stiffness, but the surface texture can be coarse, requiring filling before finishing. Birch has many sought-after qualities; however, it has a very high density, which leads to low specific stiffness. Basswood, black cherry, and red alder have grain patterns ideal for guitar tops.

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Table 11. Acoustic properties of current alternative tonewoods.

	Density, ρ (kg/m³)	MOE, E_L (GPa)	Speed of sound, c (m/s)	Mechanical impedance, z (kg/(m²s))	SRC, R (m⁴/(kg-s))
Western red cedar	370	7.66	4,550.0	1,683,508	12.3
Mahogany	590	10.06	4,129.3	2,436,268	7.0
Koa	610	10.37	4,123.1	2,515,094	6.8
Agathis	540	11.87	4,688.4	2,531,758	8.7
Walnut	610	11.59	4,358.9	2,658,928	7.1
Sinker redwood	415	8.41	4,501.7	1,868,194	10.8
Sapele	670	12.04	4,239.1	2,840,211	6.3
Maple	545	10.00	4,283.5	2,334,524	7.9
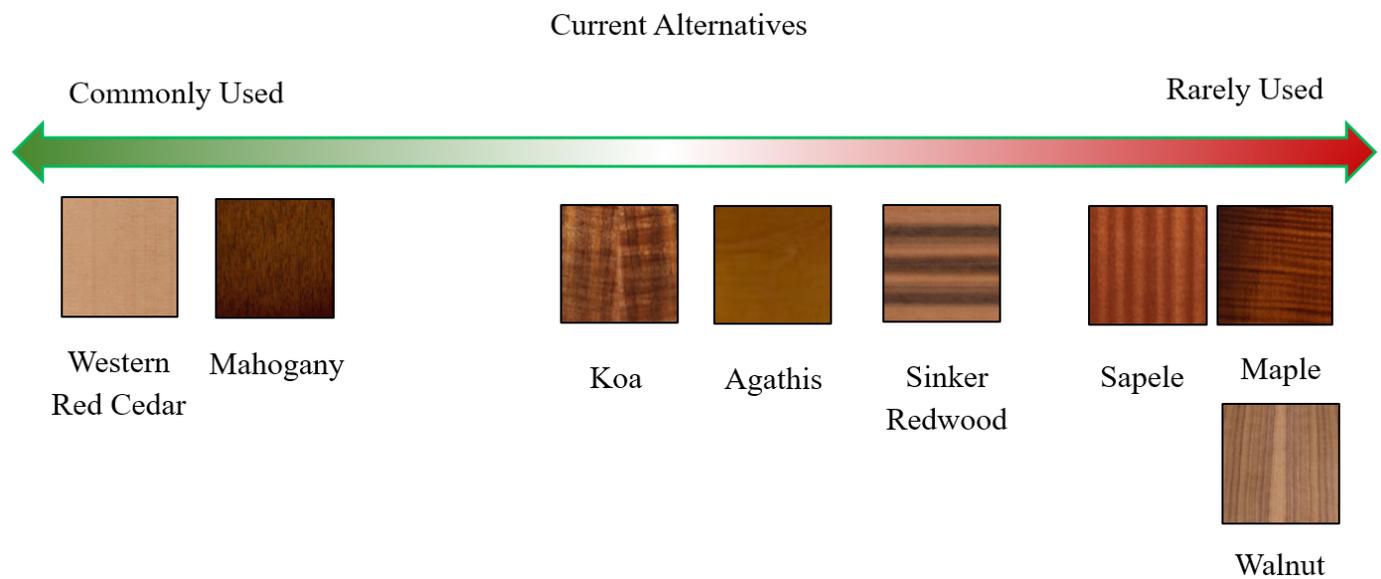
Figure 6. Order of use in industry for current alternatives (C.F. Martin & Co., Inc. 2025a; Taylor Guitars 2024a, 2024d; Andy king50 2011)

Table 12. Material properties and grain pattern descriptions for possible alternative U.S. hardwood tonewoods.

Woods	Scientific name	Density ρ (kg/m³)	MOE E_L (GPa)	Specific Stiffness (10⁶ m²/s²)	Janka hardness J (N)	Strength Σ (MPa)	Grain pattern
Basswood	*Tilia americana*	415	10.07	24.3	1820	32.6	Straight, with a fine, even texture (Meier 2015, 242)
Swamp ash*	*Fraxinus genus*	510	11.00	21.6	3780	41.2	Typically straight and regular; medium to coarse texture (Meier 2015, 131-132)
Yellow poplar	*Liriodendron tulipifera*	455	10.90	24.0	2400	38.2	straight, uniform grain, with a medium texture (Meier 2015, 156)
Black cherry	*Prunus serotina*	560	10.30	18.4	4230	49.0	Usually straight; fine, even texture (Meier 2015, 202)
Birch	*Betula alleghaniensis*	690	13.86	20.1	5610	56.3	straight or slightly wavy, with a fine, even texture (Meier 2015, 69)
Red alder	*Alnus rubra*	450	9.52	21.2	2620	40.1	Generally straight; moderately fine, uniform texture (Meier 2015, 60)

"Swamp Ash" has mechanical property values and grain pattern descriptions like black ash, except for the density. According to the Wood Database (Meier 2025), the listed density is the average density of swamp ash.

Mechanical Properties: Possible Alternatives

Best

Worst

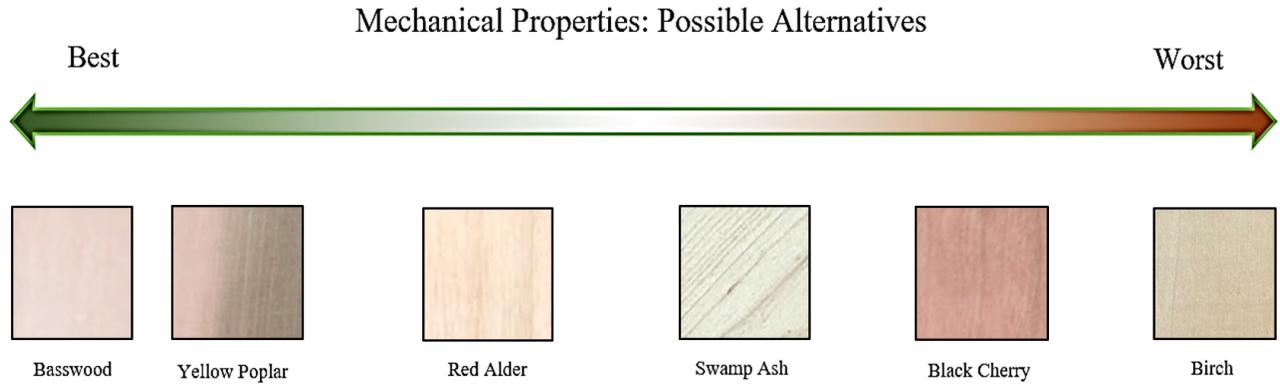| Basswood | Yellow Poplar | Red Alder | Swamp Ash | Black Cherry | Birch |

Figure 7. Ranking possible alternative U.S. hardwood tonewoods by material properties (Stephen Ondich 2020)

Table 13. Ranking assignments for each mechanical property.

	Density ρ	MOE E_L	Specific stiffness	Janka hardness J	Strength σ
5	0–450	0–9.75	24 +	4950 +	52.5 +
4	451–500	9.76–10.75	23.9–23	4949–4300	52.4–48.5
3	501–550	10.76–11.75	22.9–22	4299–3650	48.4–44.5
2	551–600	11.76–12.75	21.9–21	3649–3000	44.4–40.5
1	601–650	12.76–13.75	20.9–20	2999–2350	40.4–36.5
0	651 +	13.76 +	19.9–0	2349–0	36.4–0

A decision matrix was used to rank the wood species based on their material properties with the same methods as the other two wood groups. Tables 13–15 show the breakdown of the decision matrix, and Figure 7 shows the order of the woods from the best to the worst mechanical properties.

Material properties and aesthetics are essential for selecting tops; however, they are not the only factors to consider. Acoustic properties are just as important. Table 16 shows the calculated speed of sound, mechanical impedance, and sound radiation coefficient of each possible alternative tonewood.

Table 14. Unweighted rankings of possible U.S. hardwood tonewoods.

	Basswood	Swamp ash	Yellow poplar	Black cherry	Birch	Red alder
Density	5	3	4	2	0	5
MOE	4	3	3	4	0	5
Specific stiffness	5	2	5	0	1	2
Janka hardness	0	3	1	3	5	1
Strength	0	2	1	4	5	1
Totals	14	14	14	13	11	14

Table 15. Weighted rankings of possible U.S. hardwood tonewoods.

	Basswood	Swamp ash	Yellow poplar	Black cherry	Birch	Red alder
Density	20	12	16	8	0	20
MOE	12	9	9	12	0	15
Specific stiffness	25	10	25	0	5	10
Janka hardness	0	3	1	3	5	1
Strength	0	6	2	8	10	2
Totals	57	40	53	31	20	48

Table 16. Acoustic properties of possible U.S. hardwood tonewoods.

	Density, ρ (kg/m³)	MOE, E_L (GPa)	Speed of sound, c (m/s)	Mechanical impedance, z (kg/(m²s))	SRC, R (m⁴/(kg-s))
Basswood	415	10.07	4,926.0	2,044,272	11.9
Swamp ash*	510	11	4,644.2	2,368,544	9.1
Yellow poplar	455	10.9	4,894.5	2,226,993	10.8
Black cherry	560	10.3	4,288.7	2,401,666	7.7
Birch	690	13.86	4,481.8	3,092,475	6.5
Red alder	450	9.52	4,599.5	2,069,783	10.2

With mechanical, visual, and acoustic properties similar to those of the commonly used top woods, basswood is the clear choice as a possible hardwood alternative for guitar tops.

Discussion

Old-growth spruce tops are not a sustainable resource for the guitar industry. Major guitar manufacturers have started to move towards sustainable tonewoods, but they still use spruce for most of their acoustic guitar production. This paper demonstrates that alternative tonewoods are suitable substitutes for spruce when using mechanical, acoustic, and aesthetic characteristics. The domestic U.S. hardwoods that were most suitable were basswood and yellow poplar. With options to supplement spruce for acoustic guitar soundboards, the next step is to build guitars with tops made from basswood and yellow poplar and test them to prove whether they are practical candidates.

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